SRI VENKATESWARA COLLEGE OF ENGINEERING
(An Autonomous Institution, Affiliated to Anna University, Chennai)
SRIPERUMBUDUR TK.- 602 117
REGULATION – 2016
M.TECH BIOTECHNOLOGY
CURRICULUM AND SYLLABUS

SEMESTER I

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	MA16185	Applied Statistics for Biotechnologists	3	1	0	4
2.	BY16101	Bioprocess Technology	3	0	0	3
3.	BY16102	Computational Biology	2	0	2	3
4.	BY16103	Advanced Genetic Engineering	3	0	0	3
5.		Elective I	3	0	0	3
6.		Elective II	3	0	0	3
7.		Elective III	3	0	0	3
PRACTICALS						
8.	BY16111	Preparative and Analytical Techniques in Biotechnology Laboratory	0	0	6	3
		TOTAL	**20**	**1**	**8**	**25**

SEMESTER II

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	BY16201	Bioseparation Technology	3	0	0	3
2.	BY16202	Immunotechnology	3	0	0	3
3.	BY16203	Entrepreneurship, IPR and Biosafety	3	0	0	3
4.	BY16204	Research and Research Methodology in Biotechnology	3	0	0	3
5.		Elective IV	3	0	0	3
6.		Elective V	3	0	0	3
7.		Elective VI	3	0	0	3
PRACTICALS						
8.	BY16211	Microbial and Immuno Technology Laboratory	0	0	6	3
		TOTAL	**21**	**0**	**6**	**24**

SEMESTER III

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICALS						
1.	BY16311	Project Work (Phase I)	0	0	12	6
2.	BY16312	Advanced Molecular Biology and Genetic Engineering Laboratory	0	0	6	3
3.	BY16313	Advanced Bioprocess and Downstream Processing Laboratory	0	0	6	3
		TOTAL	**0**	**0**	**24**	**12**

SEMESTER IV

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICALS						
1.	BY16411	Project Work (Phase II)	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

ELECTIVE I

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	BY16001	Chemical Engineering for Biotechnologists	3	0	0	3
2.	BY16002	Biology for Chemical Engineers	3	0	0	3
3.	BY16003	Bioreactor Engineering	3	0	0	3
4.	BY16004	Pharmaceutical Biotechnology	3	0	0	3

ELECTIVE II

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	BY16005	Food Processing and Biotechnology	3	0	0	3
2.	BY16006	Plant Biotechnology	3	0	0	3
3.	MA16091	Applied Mathematics for Biotechnologists	3	0	0	3
4.	MA16092	Mathematics for Biotechnologists	3	0	0	3

ELECTIVE III

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	BY16007	Environmental Biotechnology	3	0	0	3
2.	BY16008	Clinical Trials and Bioethics	3	0	0	3
3.	GE16091	Unix Operating System and Programming Language C++	3	0	0	3
4.	GE16092	Communication Skills and Personality Development	3	0	0	3

ELECTIVE IV

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	BY16009	Enzyme Technology and Industrial Applications	3	0	0	3
2.	BY16010	Advanced Process Control	3	0	0	3
3.	BY16011	Bioprocess Modeling and Simulation	3	0	0	3
4.	BY16012	Plant Design and Practice	3	0	0	3

ELECTIVE V

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	BY16013	Computer Aided Learning of Structure and Function of Proteins	3	0	0	3
2.	BY16014	Metabolic Process and Engineering	3	0	0	3
3.	BY16015	Computational Fluid dynamics	3	0	0	3
4.	BY16016	Genomics and Proteomics	3	0	0	3

ELECTIVE VI

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1.	BY16017	Molecular Therapeutics	3	0	0	3
2.	BY16018	Advances in Molecular Pathogenesis	3	0	0	3
3.	BY16019	Nanobiotechnology	3	0	0	3
4.	BY16020	Animal Biotechnology	3	0	0	3

MA16185 APPLIED STATISTICS FOR BIOTECHNOLOGISTS

L	T	P	C
3	1	0	4

UNIT I **12**

Random variable - sample spaces – Events - Axiomatic approach to probability - conditional probability - additional theorem, Multiplication theorem - Baye's theorem problems - continuous and discrete random variables, Distribution function - Expectation with properties - Moments, mean, Variance problems-for continuous and discrete distributions.

UNIT II **12**

Bivariate distribution-conditional and marginal distribution-Discrete distribution-Binomial, Poisson, geometric distribution-Continuous distribution, Normal, exponential and negative exponential, gamma distributions-simple problems-properties.

UNIT III **12**

Correlation coefficient, properties-problems-Rank, correlation-Regression equations-problems-curve fitting by the method of least squares-fitting curves of the form ax+b, ax2+bx+c, abx and axb- Bivariate correlation application to biological problems.

UNIT IV **12**

Concept of sampling-Methods of sampling-sampling distributions and Standard Error-Small samples and large samples-Test of hypothesis-Type I, Type II Errors-Critical region-Large sample tests for proportion, mean-Exact test based on normal, t, f and chi-square distribution-problems-Test of goodness of fit.

UNIT V **12**

Basic principles of experimentation-Analysis of variance-one-way, Two-way classifications-Randomised block design, Latin square design-problems.

TOTAL: 60 PERIODS

TEXT BOOKS:

1. Kapoor, V.C & Gupta. Fundamentals of Mathematical statistics.10th Ed., S. Chand & sons publications, 2000.
2. Vittal,P.R. & V. Malini. Statistical and Numerical Methods, Margham Publications, 2003.
3. Veerarajan, T. Probability, Statistics and Random Processes, 3rd Ed., Tata McGraw-Hill Publications Limited, 2008.

REFERENCES:

1. Johnson, R. A. Miller & Freund's, Probability and Statistics for Engineers, 6th Ed., PHI, 2003.
2. Spiegel, Murray R., J. Schiller and R. Alu Srinivasan. Schaum's Outlines Probability and Statistics, 2nd Ed., Tata McGraw-Hill publications, 2000.
3. Arora, P.N., Smeet Aroral & S. Arora. Comprehensive Statistical Methods, 3rd Ed., S. Chand & Co, 2007.
4. Kandasamy, P. K., Thilagavathi & K. Gunavathi. Probability Statistics and Queuing Theory, Revised Ed., S. Chand & Co., 2010.

COURSE OUTCOMES

1. Basic probability axioms and rules and the moments of discrete and continuous random variables
2. Gain knowledge on Least squares, correlation, regression, consistency, efficiency and unbiasedness of estimators, method of maximum likelihood estimation and Central Limit Theorem.
3. Analyze the experiments by applying suitable non-parametric tests
4. List the guidelines for designing experiments, recognize the key historical figures in Design of

Experiments, conduct statistical tests and analyze the results

5. Provide a solid foundation on topics in statistics that can be useful for the biotechnologists to conduct research on different types of data arising in public health and clinical studies

BY16101	BIOPROCESS TECHNOLOGY	L	T	P	C
		3	0	0	3

UNIT I BLACK BOX MODEL **9**

Yield coefficients, black box stoichiometries, elemental balances, heat balance, degrees of reduction balances, systematic analysis of black box stoichiometries, and identification of gross measurement errors.

UNIT II MODELING OF VARIOUS FERMENTATION PROCESSES **9**

Principles of model building for biotechnological processes, unstructured models on the population level, structured models on the cellular level, morphologically structured model, genetically structured models, cybernetic model, modeling of recombinant systems.

UNIT III DESIGN OF FERMENTATION PROCESSES **9**

Kinetics of substrate utilization, biomass growth and product formation, inhibition on cell growth and product formation. Design and operation of continuous cultures, chemostat in series, batch and fed batch cultures, total cell retention cultivation.

UNIT IV BIOREACTOR DESIGN & CONSTRUCTION **9**

Basic design and construction of CSTR, bioreactor design of agitator/agitator motor, power consumption in aerated bioreactor, design of sparger, mixing time estimation, oxygen mass transfer capability in bioreactor, Removal of Heat in bioreactor, Main parameters to be monitored and controlled in fermentation processes.

UNIT V CASE STUDIES IN FERMENTATION DERIVED PRODUCTS **9**

Case studies on Production of green chemicals, algal biofuels, recombinant Insulin. Case studies should deal with medium design, reactor design & process optimization, etc.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Shuler, M.L. and Kargi, F., Bioprocess Engineering: Basic concepts, 2nd Ed., Prentice-Hall, 2002.
2. Doran Pauline M, Bioprocess Engineering Principles, 2nd Ed., Academic Press, 1995.
3. Nielsen, J. and Villadsen, J., Bioreaction Engineering Principles, 2nd Ed., Springer, 2007.
4. Blanch, H.W and Clark D.S., Biochemical Engineering, 2nd Ed., Marcel Dekker, 1997.

REFERENCES:

1. Bailey, J.E. and Ollis, D.F., Biochemical Engineering Fundamentals, 2nd Ed, McGraw Hill, 1986.
2. Stanbury, P.F., Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books, 2nd Ed., MPG Books Ltd, 1995.

COURSE OUTCOMES

1. Gain knowledge on the stoichiometry and energetics of product formation mediated by cell growth.
2. Apply various models to understand the kinetics and mechanism of microbial growth.
3. Design experiments and analyze data for various cultivation processes.
4. Evaluate the performance of bioreactors by optimizing different process parameters.
5. Discuss the optimization stategies for the improved product recovery.

BY16102 COMPUTATIONAL BIOLOGY

L	T	P	C
2	0	2	3

UNIT I INTRODUCTION TO COMPUTATIONAL BIOLOGY AND SEQUENCE ANALYSIS **9**

Molecular sequences, Genome sequencing: pipeline and data, Next generation sequencing data, Biological databases: Protein and Nucleotide databases, Sequence Alignment, Dynamic Programming for computing edit distance and string similarity, Local and Global Alignment, Needleman Wunsch Algorithm, Smith Waterman Algorithm, BLAST family of programs, FASTA algorithm, Functional Annotation, Progressive and Iterative Methods for Multiple sequence alignment, Applications.

UNIT II PHYLOGENETICS **7**

Introduction to Phylogenetics, Distance and Character based methods for phylogenetic tree construction: UPGMA, Neighbour joining, Ultrametric and Min ultrametric trees, Parsimonous trees, Additive trees, Bootstrapping.

UNIT III PROTEIN STRUCTURE, MODELLING AND SIMULATIONS **9**

Protein Structure Basics, Visualization, Prediction of Secondary Structure and Tertiary Structure, Homology Modeling, Structural Genomics, Molecular Docking principles and applications, Molecular dynamics simulations.

UNIT IV MACHINE LEARNING, SYSTEMS BIOLOGY AND OTHER ADVANCED TOPICS **11**

Machine learning techniques: Artificial Neural Networks and Hidden Markov Models: Applications in Protein Secondary Structure Prediction and Gene Finding, Introduction to Systems Biology and its applications in whole cell modelling, Microarrays and Clustering techniques for microarray data analysis, informatics in Genomics and Proteomics, DNA computing.

UNIT V PERL FOR BIOINFORMATICS **9**

Variables, Data types, control flow constructs, Pattern Matching, String manipulation, arrays, lists and hashes, File handling, Programs to handle biological data and parse output files for interpretation.

Laboratory Demonstrations for:

Biological Databases, Sequence alignment: BLAST family of programs, FASTA, ClustalW for multiple sequence alignment, Phylogenetics software, Homology Modeling and Model evaluation, AutoDock, GROMACS, Prokaryotic and Eukaryotic Gene finding software, Programs in PERL.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Dan Gusfield. Algorithms on Strings Trees and Sequences, Cambridge University Press, 1997.
2. David W. Mount Bioinformatics: Sequence and Genome Analysis, 2nd Ed., Cold Spring Harbor Laboratory Press, 2004.
3. Arthur M. Lesk, Introduction to Bioinformatics, 3rd Ed., Oxford University Press, 2008.
4. Tisdall, James, Beginning PERL for Bioinformatics, O'Reilley Publications, 2001.
5. Andrew R. Leach, Molecular Modeling Principles and Applications, 2nd Ed., Prentice Hall, 2001.

REFERENCES:

1. Baldi, P., Brunak, S. Bioinformatics: The Machine Learning Approach, 2nd Ed., East West Press, 2003.
2. Baxevanis A.D. and Oullette, B.F.F. A Practical Guide to the Analysis of Genes and Proteins, 2nd Ed., John Wiley, 2002.
3. Durbin, R. Eddy S., Krogh A., Mitchison G. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press, 1998.
4. Pennington. S.R and Dunn. M.J. Proteomics from protein sequence to function, Taylor and Francis Group, 2001.

COURSE OUTCOMES:

1. Apply concepts of practicing life-long learning of applied biological science
2. Develop knowledge and application of computational based solutions for biological perspectives
3. Perceive higher education in this field
4. Rule on life-long learning of applied biological science.
5. Develop bioinformatics tools with programming skills.

BY16103	ADVANCED GENETIC ENGINEERING	L	T	P	C
		3	0	0	3

UNIT I CLONING AND EXPRESSION OF GENES 10

Overview of Restriction and Modification system. Cloning vehicles: Plasmids – Host range, Copy number control, Compatibility. λ phage – Insertional and Replacement vectors, in vitro packaging. Single strand DNA vector – M13 Phage. Cosmids, Phasmids, PAC, BAC and YAC. Expression vector – Characteristics, RNA probe synthesis, High level expression of proteins, Protein solubilization, purification and export.

UNIT II CONSTRUCTION OF DNA LIBRARIES 10

DNA library – Types and importance. cDNA library: Conventional cloning strategies – Oligo dT priming, self priming and its limitations. Full length cDNA cloning – CAPture method and Oligo capping. Strategies for gDNA library construction – Chromosome walking. Differences between genomic DNA and cDNA library. Screening strategies – Hybridization, PCR, Immunoscreening, South-western and North-Western. Functional cloning – Functional complementation and gain of function. Difference cloning: Differential screening, Subtracted DNA library, differential display by PCR. Overview on microarray and its applications.

UNIT III DNA SEQUENCING 8

DNA sequencing – Importance, Chemical & Enzymatic methods, Pyrosequencing, Automated sequence, Genome sequencing methods – top down approach, bottom up approach.

UNIT IV PCR AND MUTAGENESIS 9

PCR – Principle and applications. Different types of PCR – Hot start PCR, Touchdown PCR, Multiplex PCR, Inverse PCR, Nested PCR, AFLP-PCR, Allele specific PCR, Assembly PCR, Asymmetric PCR, LATE-PCR, Colony PCR, in situ PCR, Long PCR. Real-time PCR – SYBR Green assay, Taqman Probes, Molecular beacons. Mutagenesis and chimeric protein engineering by PCR, RACE, Kuntels' method of mutagenesis.

UNIT V GENE TRANSFER & GENE THERAPY 8

Introduction of foreign genes into animal cells – Importance, DNA Microinjection, Retroviral

vectors, Transfection of Embryonic stem cells, recombination. Transgenic plants – Importance, Ti Plasmid, Co integrate and Binary vectors. Overview of Gene therapy.

TOTAL: 45 PERIODS

REFERENCES:

1. Primrose, S.B., Twyman, R.H., & Old, R.W., Principles of Gene Manipulation, 6th Ed., Blackwell Science, 2001.
2. Winnacker, E.L., From Genes to clones: Introduction to Gene Technology, Panima Publishing Corporation, 2003.
3. Glick, B.R., & Pasternak, J.J., Molecular Biotechnology: Principles and applications of recombinant DNA, 3rd Ed., ASM Press, 2003.
4. Lemonie, N.R., & Cooper, D.N., Gene therapy, Oxford BIOS Scientific Publishers, 1996.

COURSE OUTCOMES:

1. Outline the concepts on gene cloning methods, tools and techniques involved in genome analysis and genomics
2. Delineate various studies and techniques of heterologous expression of cloned genes in different hosts using DNA library construction.
3. Explain the core priciple of PCR techniques and thier application in gene modifications.
4. Develop the knowledge on various DNA sequensing and mutagenesis studies for the development gene modified organisms.
5. Practice the latest application of recombinant technology in gene therapy and protein science research.

BY 16111 PREPARATIVE AND ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY LABORATORY **L T P C 0 0 6 3**

1. Preparation of Acetate, Tris and Phosphate Buffer systems and validation of Henderson - Hasselbach equation.
2. Reactions of amino acids – Ninhydrin, Pthaldehyde, Dansyl chloride – measurement using colorimetric and fluorimetric methods.
3. Differential estimations of carbohydrates – reducing vs non-reducing, polymeric vs oligomeric, hexose vs pentose.
4. Estimation of protein concentration using Lowrys' method, Dye-binding method.
5. DNA determination by UV-Vis Spectrophotometer – hyperchromic effect Separation of lipids by TLC.
6. Enzyme Kinetics: Direct and indirect assays – determination of Km, Vmax and Kcat, Kcat/Km.
7. Restriction enzyme – Enrichment and unit calculation.
8. Ion-exchange Chromatography – Purification of IgG and Albumin.
9. Gel filtration – Size based separation of proteins.
10. Affinity chromatography – IMAC purification of His-tagged recombinant protein.
11. Assessing purity by SDS-PAGE Gel Electrophoresis.
12. Chemical modification of proteins – PITC modification of IgG and Protein immobilization.

TOTAL: 90 PERIODS

REFERENCES:

1. Pingoud, I., Urbanke, C., Hoggett, J., & Jeltsch, A., Biochemical Methods: A Concise Guide for Students and Researchers, John Wiley & Sons Publishers, Inc., 2002.
2. Segel, I.H., Biochemical Calculations: How to Solve Mathematical Problems in General

Biochemistry, 2nd Ed., John Wiley & Sons Publishers, Inc., 1976.
3. Wilson, K. & Walker, J., Principles and Techniques of Practical Biochemistry, 5th Ed., Cambridge University Press, 2000.

COURSE OUTCOMES:

1. Create awareness about the hazardous chemicals and safety precautions in case of emergency.
2. Learn about the qualitative and quantitative estimation of biomolecules.
3. Elaborate the working principle of instruments (pH meter and spectroscopy) used in biochemistry lab.
4. Analyze the significance of biochemistry in research and clinical sample analysis.
5. Demonstrate the application of spectroscopic methods in quantification of bioproducts.

BY16201	**BIOSEPARATION TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I INTRODUCTION TO BIOSEPARATION 4

Characterization of biomolecules and fermentation broth. Guidelines to recombinant protein purification.

UNIT II SOLID-LIQUID SEPARATION AND CELL DISRUPTION 6

Solid liquid separation: Microfiltration and Centrifugation – Theory and design for scale up operation. Cell disruption: Homogenizer and Dynomill – Principle and factors affecting disruption. Batch and continuous operation. Cell disruption by chemical methods.

UNIT III CONCENTRATION AND PURIFICATION 7

Liquid - liquid extraction – Theory and practice, with emphasis on Aqueous two phase extraction. Solid liquid extraction. Precipitation techniques using salt and solvent. Separation by Ultrafiltration, Dialysis and Electrophoresis.

UNIT IV CHROMATOGRAPHY 15

Gel filtration chromatography, Ion exchange chromatography, Hydrophobic interaction chromatography, Reverse phase chromatography, Expanded bed chromatography &. Affinity chromatography – Metal affinity chromatography, Dye affinity chromatography, Immunosorbent affinity chromatography: Theory, practice and selection of media. Scale up criteria for chromatography, calculation of number of theoretical plates and design.

UNIT V FINAL POLISHING AND CASE STUDIES 13

Freeze drying, spray drying and crystallization. Purification of Cephalosporin, Aspartic acid, Recombinant Streptokinase, Monoclonal antibodies, Tissue plasminogen activator, Taq polymerase and Insulin.

TOTAL: 45 PERIODS

TEXT BOOKS/ REFERENCES:

1. Belter, P.A., Cussler, E.L., & Hu, W.S. Bioseparations: Downstream Processing For Biotechnology, John- Wiley, 1988.
2. Janson, J.C. Protein Purification: Principles, High Resolution Methods and Applications, 3rd Ed., VCH Pub., 2011.
3. Scopes, R.K. Protein Purification – Principles and Practice, 3rd Ed., Springer, 1994.

COURSE OUTCOMES:

1. Understand the importance of bioseparation and nature of the fermentation broth and biomolecules to select an appropriate purification process.
2. Select the appropriate cell disruption method used for the recovery of intracellular products.
3. Choose the appropriate extraction and precipitation methods used for the separation of biomolecules.
4. Select an appropriate chromatographic separation method to achieve maximum purity of target product.
5. Apply the principles of drying and crystallization to obtain the final polished desired biomolecule.

BY16202	IMMUNOTECHNOLOGY	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION **12**

Cells of the immune system and their development; primary and secondary lymphoid organs; humoral immune response; cell mediated immune responses; complement.

UNIT II ANTIBODIES **10**

Monoclonal antibodies and their use in diagnostics; ELISA; Agglutination tests; Antigen detection assay; Plaque Forming Cell Assay.

UNIT III CELLULAR IMMUNOLOGY **12**

PBMC separation from the blood; identification of lymphocytes based on CD markers; FACS; Lympho -proliferation assay; Mixed lymphocyte reaction; Cr51 release assay; macrophage cultures; cytokine bioassays- IL2, gamma IFN, TNF alpha; HLA typing.

UNIT IV VACCINE TECHNOLOGY **6**

Basic principles of vaccine development; protein based vaccines; DNA vaccines; Plant based vaccines; recombinant antigens as vaccines; reverse vaccinology.

UNIT V DEVELOPMENT OF IMMUNOTHERAPEUTICS **5**

Engineered antibodies; catalytic antibodies; Idiotypic antibodies; combinatorial libraries for antibody isolation.

TOTAL: 45 PERIODS

TEXT BOOKS/ REFERENCES:

1. Roitt, Ivan. Essential Immunology, 9th Ed., Blackwell Scientific, 1997.
2. Roitt, I., Brostoff, J & Male, D. Immunology, 6th Ed. Mosby, 2001.
3. Goldsby, R.A., Kindt, T.J., Osbome, B.A & Kerby, J. Immunology, 5th Ed., W.H Freeman, 2003.
4. Weir, D.M & Stewart, J. Immunology, 8th Ed., Churchill Livingstone, 1997.

COURSE OUTCOMES:

1. Classify different types of immune cells and immune response
2. Outline the uses of monoclonal antibodies in diagnostics and therapeutics

3. Experiment with immune cells and the cytokine assays
4. Explain about different types of vaccines and its uses
5. Classify antibodies and their application in the treatment of various diseases

BY16203 ENTREPRENEURSHIP, IPR AND BIOSAFETY

L	T	P	C
3	0	0	3

UNIT I ENTREPRENEURSHIP **10**

Definition - functions and kinds of entrepreneurs. Entrepreneur, Entrepreneurship and economic development, entrepreneurial competencies and traits, developing competencies. Project identification, selection and financing. Project report - content and significance, Planning Commission's guidelines for formulating project reports. Methods of project appraisals.

UNIT II INTRODUCTION TO INTELLECTUAL PROPERTY **10**

Types of Intellectual property (IP): Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs. IP as a factor in R&D, IPs of relevance to Biotechnology Agreements and Treaties. History of GATT & TRIPS Agreement, Madrid Agreement; Hague Agreement, WIPO Treaties, Budapest Treaty, PCT, Indian Patent Act 1970 & recent amendments, Case Studies.

UNIT III BASICS OF PATENTS AND CONCEPT OF PRIOR ART **8**

Introduction to Patents, Types of patent applications - Ordinary, PCT, Conventional, Divisional and Patent of Addition, Specifications - Provisional and complete, Forms and fees Invention in context of "prior art", Patent databases, Searching International Databases, Country-wise patent searches (USPTO, espacenet (EPO), PATENT Scope (WIPO), IPO).

UNIT IV PATENTING PROCEDURES **7**

National & PCT filing procedure, Time frame and cost, Status of the patent applications filed, Precautions while patenting – disclosure/non-disclosure, Financial assistance for patenting - introduction to existing schemes. Patent licensing and agreement. Patent infringement- meaning, scope, litigation, case studies.

UNIT V BIOSAFETY **10**

Introduction, Historical Background, Introduction to Biological Safety Cabinets, Primary Containment for Biohazards, Biosafety Levels, Biosafety Levels of Specific Microorganisms, Recommended Biosafety Levels for Infectious Agents and Infected Animals, Biosafety guidelines - Government of India. Definition of GMOs & LMOs, Roles of Institutional Biosafety Committee, RCGM, GEAC for GMO applications in food and agriculture. Environmental release of GMOs, Risk Analysis, Risk Assessment, Risk management and communication, Overview of National Regulations and relevant International Agreements including Cartegana Protocol.

TOTAL: 45 PERIODS

TEXT BOOKS/ REFERENCES:

1. BAREACT. Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007.
2. Kankanala, C. Genetic Patent Law & Strategy, 1st Ed., Manupatra Information Solution Pvt. Ltd., 2007.
3. Kanka, S.S. Entrepreneurship Development, 1st Ed., S. Chand and Co, 1997.

COURSE OUTCOMES:

1. Outline the IPR policy and patent filing process
2. Utilize the intellectual property rights for protecting the scientific/technical knowledge
3. Examine codes/regulations of bioethics in protecting environment and safety of society
4. Simplify necessary planning for model preparation evaluation and new products development.
5. Identify the legislative provisions regulating patents and organize the work flow for obtaining patent.

BY16204	RESEARCH AND RESEARCH METHODOLOGY IN BIOTECHNOLOGY	L T P C 3 0 0 3

UNIT I RESEARCH AND ITS METHODOLOGIES (WITH EXAMPLES) 9

Objectives of research, research process – observation, analysis, inference, hypothesis, axiom, theory, experimentation, types of research (basic, applied, qualitative, quantitative, analytical etc). Features of translational research, the concept of laboratory to market (bench to public) and Industrial R&D.

UNIT II RESEARCH IN BIOTECHNOLOGY – AN OVERVIEW 9

Biological systems and their characteristic: Type and outcome of research, Exploratory and product-oriented research in various fields of biotechnology (health, agri, food, industrial etc) – types of expertise and facilities required. Interdisciplinary nature of biotech research, sources of literature for biotech research.

UNIT III EXPERIMENTAL RESEARCH: BASIC CONCEPTS IN DESIGN AND METHODOLOGY 9

Precision, accuracy, sensitivity and specificity; variables, biochemical measurements, types of measurements, enzymes and enzymatic analysis, antibodies and immunoassays, instrumental methods, bioinformatics and computation, experimental planning – general guidelines.

UNIT IV RESULTS AND ANALYSIS 9

Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective) and cross verification, correlation with published results, discussion, outcome as new idea, hypothesis, concept, theory, model etc.

UNIT V SCIENTIFIC AND TECHNICAL PUBLICATION 9

Different types of scientific and technical publications in the area of biotechnology, and their specifications, Ways to protect intellectual property – Patents, technical writing skills, definition and importance of impact factor and citation index - assignment in technical writing.

TOTAL: 45 PERIODS

REFERENCES:

1. Marczyk, G.R., DeMatteo, D. & Festinger, D. Essentials of Research Design and Methodology, John Wiley & Sons Publishers Inc, 2005.
2. Segel, I.H. Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, 2nd Ed., John Wiley & Sons Publishers Inc, 1976.
3. Korner, A.M. Guide to Publishing a Scientific paper, Bioscript Press, 2004.

COURSE OUTCOMES:

1. Determine how to perform research process in biotechnology
2. Implement research process knowledge on designing experimental research
3. Prepare types of measurements, immunoassays, instrumental methods, bioinformatics and computation and experimental planning in research.
4. Validate results, discussion, hypothesis, concept, theory, model etc.
5. Compose technical report design, prepare scientific journals and post the publication.

BY16211	**MICROBIAL AND IMMUNO TECHNOLOGY LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**6**	**3**

PART I MICROBIAL TECHNOLOGY

1. Disinfection, safety instructions; Preparation of media and Sterilization.
2. Identification and staining of microbes (gram staining, Giemsa etc).
3. Enumeration of microorganisms by serial dilution.
4. Growth curve, measure of bacterial population by turbidometry.

PART II IMMUNOTECHNOLOGY

5. Ethics, selection and handling of animals for immunological experiments (Eg. Mice, Rats, Rabbits).
6. Preparation of antigen and Routes of immunisation (Intra-peritonial, Sub-cutaneous, Intramuscular, Intra-nasal, Oral).
7. Methods of bleeding (Eg. Tail bleeding, Intravenous, Intraorbital).
8. Collection of serum, storage and purification of total IgG (Salt Precipitation).
9. Evaluation of Antibody titre by direct ELISA.
10. Evaluation of Antigen by Sandwich ELISA.
11. Characterization of antigens by native, SDS-PAGE.
12. Characterization of antigens by Immunoblotting.
13. Conjugation of Immunoglobulins (Streptavidin, colloidal gold).
14. Methods for prototype development of Immunodiagnostics (ICT card).
15. Blood smear identification of leucocytes by Giemsa stain.
16. Separation of mononuclear cells by Ficoll-Hypaque.
17. Separation of spleenocytes and proliferation against mitogens.

TOTAL: 90 PERIODS

REFERENCES:

1. Harlow, E.d. & David, P. L. Antibodies: A Laboratory Manual, 2nd Ed., Cold Spring Harbor Laboratory Press, 1998.
2. Joseph, S & David, W. R. Molecular cloning: A Laboratory Manual, 3rd Ed., Cold Spring Harbor Laboratory Press, 2001.
3. John, E. C. Current Protocols in Immunology, Wiley Interscience, 2003.

COURSE OUTCOMES:

1. Skill to handle the microbes, identify the microbes using statining protcol and cultivate using artificial media.
2. Acquire knowledge on basic animal handling strategies
3. Evaluate the presence of antibodies and antigens from the given samples using immunological techniques
4. Identify and inspect various blood cells using staining techniques

BY16312	ADVANCED MOLECULAR BIOLOGY AND GENETIC ENGINEERING LABORATORY	L	T	P	C
		0	0	6	3

OBJECTIVES:

- To train the students for preparing biomolecules such as DNA, RNA, cDNA and to perform the techniques such as Southern Blotting, Western Blotting, ELISA, EMSA and PCR.

LIST OF EXPERIMENTS:

1. Isolation of DNA
2. Chemical Transformation and Electroporation of Bacteria
3. Isolation of RNA
4. cDNA synthesis
5. Real-time PCR
6. Enzyme Linked Immunosorbent Assay (ELISA)
7. Western blot
8. Site directed mutagenesis
9. Southern blot (Non-radioactive)
10. Restriction Digestion and Ligation

TOTAL: 45 PERIODS

OUTCOMES:

- At the end of the course the students will be able to individually perform techniques such as Isolation of DNA, RNA and cDNA.
- At the end of the course the students will be able to individually perform techniques such as Southern Blotting, Western Blotting, ELISA, EMSA and PCR for detection of DNA, Protein and Protein-DNA Complex.

REFERENCES:

1. Joe Sambrook and David William Russel. “Molecular cloning: A laboratory manual”, CSHL press.

COURSE OUTCOMES:

1. Illustrate the techniques used to isolate DNA/RNA and synthesize cdna
2. Perform techniques such as Southern Blotting, Western Blotting, ELISA, EMSA and PCR for detection of DNA, Protein and Protein-DNA Complex.

LIST OF EQUIPMENT FOR A BATCH OF 18 STUDENTS

1.	DNA Electrophoresis Units	4
2.	SDS – PAGE Units	4
3.	37°C Incubator	1
4.	Shaker (room temperature)	1
5.	PCR machine	1
6.	Centrifuge - Non-Refrigerated	2
7.	Centrifuge – Refrigerated	1
8.	Laminar Hood	1
9.	-20° C deep freezer	1
10.	Refrigerator	1
11.	UV – Transilluminator	1
12.	Gel documentation system	1
13.	Spectrophotometer UV range	1
14.	Ice making machine	1
15.	Micro oven	1
16.	Rocker	2
17.	Western blot apparatus	1
18.	ELISA plate Reader	1
19.	Southern blot – Hybridization oven	1
20.	Water bath (10 – 60°C)	1
21.	Electroporator	1

BY16313	ADVANCED BIOPROCESS AND DOWNSTREAM PROCESSING LABORATORY	L	T	P	C
		0	0	6	3

OBJECTIVES:

- To train the students in production and purification of bioproducts.

LIST OF EXPERIMENTS:

1. Enzyme kinetics, inhibition, factors affecting reaction pH, temp.
2. Enzyme immobilization studies – Gel entrapment, adsorption and ion exchange
3. Optimization techniques – Plackett burman, Response surface methodology.
4. Batch cultivation – recombinant *E. coli* – growth rate, substrate utilization kinetics,
5. Plasmid stability, product analysis after induction, Metabolite analysis by HPLC
6. Fed batch cultivation *E. coli, Pichia pastoris*
7. Continuous cultivation – x - d construction, kinetic parameter evaluation, gas analysis, carbon balancing, Pulse and shift techniques.
8. Bioreactor studies : Sterilization kinetics, k_La determination, residence time distribution
9. Animal cell culture production: T-flask, spinner flask, bioreactor
10. Cell separation methods; Centrifugation and microfiltration
11. Cell disruption methods: Chemical lysis and Physical methods
12. Product concentration: Precipitation, ATPS, Ultrafiltration
13. High resolution purification; Ion exchange, affinity and Gel filtration
14. Freeze drying

TOTAL: 45 PERIODS.

REFERENCES:

1. Bailey, J.E & Ollis, D.F., "Biochemical Engineering Fundamentals", 3rd edition, McGraw Hill, 2011.
2. Belter, P.A., Cussler, E.L., and Houhu, W "Bioseparations – Downstream Processing For Biotechnology", Wiley Interscience Publication, 2011.
3. Janson J.C. and L. Ryden, (Ed.) – Protein Purification – Principles, High Resolution Methods And Applications, 3rd Edition, Wiley-VCH Publication, 2011.

COURSE OUTCOMES:

1. Select the appropriate enzymes used for reactions and bioreactors in its immobilized form.
2. "Perform optimization of media components and process parameters and the different kinds
3. bioreactors"
4. "Inspect the importance of mixing time, residence time and oxygen demand in the growing
5. cultures. "
6. Experiment with the different kinds of bioreactors for animal cell culture production
7. Make use of various separation techniques for product purification and preservation.

BY16001 CHEMICAL ENGINEERING FOR BIOTECHNOLOGISTS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION **5**

Introduction to chemical engineering sciences and its role in the design & analysis of chemical processes. Overview of unit operations and processes in the chemical industry. Units and conversion factor. Introduction to Dimensional analysis.

UNIT II MATERIAL AND ENERGY BALANCES **13**

Overall and component material balances - Material balances without chemical reactions - Chemical reactions -stoichiometry - conversion and yield - Material balance calculations with chemical reactions – combustion calculations - recycle operations. Energy balances - Entropy - Latent heat - Chemical reactions - combustion. Concepts of chemical thermodynamics, the relation to VLE, solution thermodynamics and reaction thermodynamics.

UNIT III FLUID MECHANICS **9**

Properties of fluids; Fluid statics – forces at fluid surfaces, Pressure and measurement of pressure differences; Fluid flow concepts and basic equations of fluid flow – continuity equation and Bernoulli's equation; shear stress relationship and viscous effects in fluid flow; non-Newtonian fluids; significance of dimensionless groups in fluid flow operations.

UNIT IV TRANSPORTATION OF FLUIDS **9**

Different types of pumps, compressors and valves. Measurement of fluid flow using hydrodynamic methods, direct displacement method. Types of agitators, flow patterns in agitated vessels, calculation of power consumption – applications in bioreactor design.

UNIT V HEAT TRANSFER **9**

Nature of heat flow - Conduction, convection, radiation. Steady state conduction, Principles of heat flow in fluids, Heat transfer by forced convection in laminar and turbulent flow. Heat exchange equipments- principles and design.

TOTAL: 45 PERIODS

REFERENCES:

1. Bhatt, B.I. & Vora, S.M., Stoichiometry, 3rd Ed., Tata McGraw-Hill Inc., 1977.
2. McCabe W.L., Smith, J.C. & Harriott, P., Unit Operations In Chemical Engineering, 6th Ed., McGraw-Hill Inc., 2001.
3. Geankoplis, C.J., Transport Processes And Unit Operations, 3rd Ed., Prentice Hall India, 2003.

COURSE OUTCOMES:

1. Gain knowledge on unit operations and processes in the chemical industries.
2. Apply concepts of material and energy balance in bioprocess calculations.
3. Develop the knowledge on fluids, fluid flow and mixing in bioprocesses
4. Explain the applications of fluid flow and mixing in bioprocess operations
5. Analyze the principles and applications of heat transfer operations in bioprocesses.

BY16002 BIOLOGY FOR CHEMICAL ENGINEERS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO BIOLOGICAL MOLECULES 9

Basic Carbon Chemistry, Types of biomolecules, Molecular structure and function of Biological Macromolecules - Proteins, Nucleic acids, Carbohydrates, Lipids.

UNIT II GENES TO METABOLIC END-PRODUCTS 9

Basics of DNA replication, transcription, translation, biocatalysis, pathways and metabolism.

UNIT III MOLECULAR CELL BIOLOGY AND ENERGETICS 9

Functional organization of cells at molecular level; membranes, molecular communication across membranes, energetics – proton motive force, ATP synthesis, respiration; photosynthesis.

UNIT IV MOLECULAR BASIS OF MICROBIAL FORMS AND THEIR DIVERSITY 9

Structural differences between different microbial cell types; over view of primary and secondary metabolism of microbes, commercial products like antibiotics, vitamins from microbes.

UNIT V MOLECULAR BASIS OF HIGHER LIFE FORMS 9

Molecular differences between various eukaryotic cell types, tissue proteins, blood, important molecular components of blood, albumin, antibodies, hormones and their actions.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Rodney Boyer, Interactive Concepts in Biochemistry, 2nd Ed., John Wiley & Sons Publishers Inc., Copy Right, 2002.
2. http://www.wiley.com/legacy/college/boyer/0470003790/index.htm
3. Lubert Stryer, Biochemistry, 5th Ed., W. H. Freeman & Company, 2002.
4. David L. Nelson & Michael M. Cox, Lehninger's Principles of Biochemistry, 4th Ed, W. H. Freeman & Company, 2004.
5. Harvey Lodish, Arnold Berk, Chris A.Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira, Molecular Cell Biology, 3rd Ed., W. H. Freeman & Company, 1995.
6. D. A. Harris, Bioenergetics at a Glance: An Illustrated Introduction, 6th Ed., John Wiley & Sons Publishers Inc., 1995.
7. Morris Hein, Leo, R. Best, Scott Pattison & Susan Arena, Introduction to General, Organic, and Biochemistry, 8th Ed., John Wiley & Sons Publishers Inc., 2004.
8. Michael Wink (Editor), An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology, 2nd Ed., John Wiley & Sons Publishers Inc., 2006.

COURSE OUTCOMES:

1. Distinguish the structure and function of prokaryotic and eukaryotic cells.
2. Explain the usage of biological principles in engineering.
3. Integrate the concepts of biology with engineering through case studies.
4. Describe the influence of biologically inspired materials/machine/devices on environment and society.
5. Explicit the regulations, ethics, security and safety of engineering applications.

BY16003 BIOREACTOR ENGINEERING

L	T	P	C
3	0	0	3

UNIT I TRANSPORT PROCESS IN BIOREACTOR 9

Gas-liquid mass transfer in cellular systems, determination of oxygen transfer rates, mass transfer for freely rising or falling bodies, forced convection mass transfer, Overall kLa estimation and power requirements for sparged and agitated vessels, mass transfer across free surfaces, other factors affecting kLa, non-Newtonian fluids, Heat transfer correlations, thermal death kinetics of microorganisms, batch and continuous heat, sterilization of liquid media, filter sterilization of liquid media, Air. Design of sterilization equipment batch and continuous.

UNIT II MONITORING OF BIOPROCESSES 6

On-line data analysis for measurement of important physico-chemical and biochemical parameters; Methods of on-line and off-line biomass estimation; microbial calorimetry; Flow injection analysis for measurement of substrates, product and other metabolites; State and parameter estimation techniques for biochemical processes. Case studies on applications of FIA and Microbial calorimetry.

UNIT III MODERN BIOTECHNOLOGICAL PROCESSES 14

Recombinant cell culture processes, guidelines for choosing host-vector systems, plasmid stability in recombinant cell culture, limits to over expression, Modelling of recombinant bacterial cultures; Bioreactor strategies for maximizing product formation; Case studies on high cell density cultivation and plasmid stabilization methods. Bioprocess design considerations for plant and animal cell cultures. Analysis of multiple interacting microbial populations –competition: survival of the fittest, predation and parasitism: Lotka Volterra model.

UNIT IV DESIGN AND ANALYSIS OF BIOLOGICAL REACTORS 11

Ideal bioreactors-batch, fed batch, continuous, cell recycle, plug flow reactor, two stage reactors, enzyme catalyzed reactions. Reactor dynamics and stability. Reactors with non-ideal mixing. Other types of reactors- fluidized bed reactors; packed bed reactors, bubble column reactors, trickle bed reactors.

UNIT V SCALE UP OF REACTORS 5

Similitude, oxygen transfer, power correlations, mixing time.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Anton Moser, Bioprocess Technology: Kinetics and Reactors, Springer-Verlag, 1988.
2. Bailey J.E. & Ollis, D.F., Biochemical Engineering Fundamentals, 2nd Ed., McGraw Hill Inc.,1986.
3. James M. Lee, Biochemical Engineering, Prentice Hall Inc., 1992.
4. Blanch, H.W. & Clark, D.S., Biochemical Engineering, Marcel Decker, 1996.
5. Atkinson, B., Biochemical Reactor, Pion Ltd., London, UK, 1974.

COURSE OUTCOMES:

1. Develop the design equations for bioreactors and calculate the oxygen demand for cell growth.
2. Identify suitable process instrumentation for monitoring and control of bioreactors.
3. Analyze the performance of reactors using segregation models for the modern Biotechnological processess
4. Design batch, continuous flow, and fed batch reactors for enzymatic reactions
5. Scale-up of bioreactors on the basis of rule of thumbs.

BY16004	**PHARMACEUTICAL BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I INTRODUCTION **8**

History of pharmaceutical industry, Drugs discovery and Development phases; Drugs and Cosmetics ACT and regulatory aspects; Definition: Generics and its advantages; Biogenerics and Biosimilars; The role of patents in the drug industry; Protein-based biopharmaceuticals; International Non-proprietary Names (INN) nomenclature system biosimilars regulation.

UNIT II DOSAGE FORM: SCIENCE, PHARMACOKINETICS AND PHARMACODYNAMICS **10**

Definition of Dosage forms, Classification of dosage forms (solid unit dosages – Tablets, capsules; liquids – solutions, lotions, suspension etc; semi-solid – ointments, creams, gel, suppositories, etc; Parenterals, Aerosols etc), Introduction to pharmacokinetics and pharmacodynamic principles (factors affecting the ADME process); bioavailability, bioequivalence.

UNIT III DRUG DELIVERY AND CHARACTERISATION OF BIOENERGIC RECOMBINANTS **9**

Advanced drug delivery systems – controlled release, transdermals, liposomes and drug target in Approaches to the characterization of biosimilars; Problems in characterizing biologics (Types of biologic, Peptides, Non-glycosylated proteins, Glycosylated proteins, Monoclonal antibodies); Equivalence issues; Post-translational modifications; Effect of micro heterogeneity.

UNIT IV PHARMACOLOGY PRINCIPLES, CLASSIFICATION OF DRUGS AND MECHANISM **10**

Understanding principles of pharmacology, pharmacodynamics Study of a few classes of therapeutics like laxatives, antacids and drugs used in peptic ulcers, drugs used in coughs and colds, analgesics, contraceptives, antibiotics (folate inhibitors, protein synthesis inhibitors, DNA inhibitors), hormonal agonists and antagonists.

UNIT V CASE STUDIES ON BIOPHARMACEUTICAL PRODUCT DEVELOPMENT **8**

Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocyte - macrophage CSF, Factor VIIa, Factor IX, Factor VIII, Tissue plasminogen activator, Monoclonal antibodies and engineered Mabs.

TOTAL: 45 PERIODS

REFERENCES:

1. Gareth Thomas., Medicinal Chemistry- An introduction, 2nd Ed., John Wiley, 2007.
2. Katzung B.G., Basic and Clinical Pharmacology, 12th Ed., Mc Graw Hill, 2011.
3. Ramabhadran, T.V., Pharmaceutical Design And Development: A Molecular Biology Approach, Ellis Horwood Publishers, 2005.
4. Goodman & Gilman's., The Pharmacological Basis of Therapeutics, 11th ed., McGraw- Hill Medical Publishing Division, 2006.

5. Sarfaraz K. Niazi., Handbook of Biogeneric Therapeutic Proteins: Regulatory, Manufacturing, Testing, and Patent Issues, CRC Press, 2006.
6. Rodney J Y Ho & MILO Gibaldi., Biotechnology & Biopharmaceuticals Transforming proteins and genes into drugs, 1st Ed., Wiley Liss, 2003.
7. Brahmankar D M & Jaiswal S B., Biopharmaceutics and Pharmacokinetics A Treatise, Vallabh Publisher, 2008.

COURSE OUTCOMES:

1. Acquire the knowledge about the legal steps involved in progressing a new drug to market and to grab the current regulatory acts and safety norms of the modern pharmaceutical industries.
2. Understand the mechanism of drug action and pharmacokinetics of a given drug. This course also felicitates the students to understand and evaluate different pharmaceutical parameters for the current and future biotechnology related products on the market.
   Gain the knowledge about the different types of drug delivery systems and effect of post translational modification and microheterogenecity on drug delivery process.
3. Elaborate their knowledge on pharmacodynamics of pharmaceutical products and current medicines.
4. Analyse the novel biotechnological and pharmaceutical products, current medicines and their applications in therapeutic and diagnostic fields.

BY16005	FOOD PROCESSING AND BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

UNIT I FOOD CHEMISTRY **9**

Constituent of food – contribution to texture, flavour and organoleptic properties of food; food additives – intentional and non-intentional and their functions; enzymes in food processing.

UNIT II FOOD MICROBIOLOGY **9**

Sources and activity of microorganisms associated with food; food fermentation; food chemicals; food borne diseases – infections and intoxications, food spoilage – causes.

UNIT III FOOD PROCESSING **9**

Raw material characteristics; cleaning, sorting and grading of foods; physical conversion operations – mixing, emulsification, extraction, filtration, centrifugation, membrane separation, crystallization, heat processing.

UNIT IV FOOD PRESERVATION **9**

Use of high temperatures – sterilization, pasteurization, blanching, aseptic canning; frozen storage – freezing curve characteristics. Factors affecting quality of frozen foods; irradiation preservation of foods.

UNIT V MANUFACTURE OF FOOD PRODUCTS **9**

Bread and baked goods, dairy products – milk processing, cheese, butter, ice-cream, vegetable and fruit products; edible oils and fats; meat, poultry and fish products; confectionery, beverages.

TOTAL: 45 PERIODS

REFERENCES:

1. Coultate, T.P. Food – The chemistry of its components, 2nd Ed., Royal society, 1992.
2. Sivasankar, B. Food processing and preservation, Prentice Hall of India Pvt. Ltd., 2002.
3. Fennema, O.R. Principles of food science: Part I, Food chemistry, Marcel Dekker, 1976.

4. Frazier, W.C. & Westhoff, D.C. Food Microbiology, 4th Ed. McGram-Hill Book Co., 1988.
5. Brenner, J.G., Butters, J.R., Cowell, N.D. & Lilly, A.E.V. Food Engineering Operations, 2nd Ed., Applied Sciences Pub. Ltd., 1979.
6. Pyke, M. Food Science and Technology, 4th Ed., John Murray, 1981.

COURSE OUTCOMES:

1. Understand the various constituents present in food and its significance in food processing.
2. Understand the importance of microorganisms and its role in processing of food.
3. Choose the appropriate unit operations used in modern food processing and its impact on food quality.
4. Make use of the principles and importance of preservation techniques used in food processing.
5. Apply the fundamentals of food processing for manufacturing food products.

BY16006	**PLANT BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I INTRODUCTION TO PLANT MOLECULAR BIOLOGY 9

Genetic material of plant cells, nucleosome structure and its biological significance; transposons; outline of transcription and translation, alternative and trans splicing, constitutive and differentially expressed genes in plants.

UNIT II CHLOROPLAST AND MITOCHONDRIA 9

Structure, function: Light and dark reaction and genetic material; rubisco synthesis and assembly, coordination, regulation and transport of proteins. Mitochondria: Genome, cytoplasmic male sterility and import of proteins, comparison and differences between mitochondrial and chloroplast genome, chloroplast transformation.

UNIT III PLANT METABOLISM AND METABOLIC ENGINEERING 8

Nitrogen fixation, Nitrogenase activity, nod genes, nif genes, bacteroids, plant nodulins, production of secondary metabolites, flavanoid synthesis and metabolic engineering.

UNIT IV AGROBACTERIUM AND PLANT VIRUSES 9

Pathogenesis, crown gall disease, genes involved in the pathogenesis, Ti plasmid – T- DNA, importance in genetic engineering. Plant viruses and different types, Viral Vectors: Gemini virus, cauliflower mosaic virus, viral vectors and its benefits, vectors used for plant transformation, Methods used for transgene identification.

UNIT V APPLICATIONS OF PLANT BIOTECHNOLOGY 10

Outline of plant tissue culture, transgenic plants, herbicide and pest resistant plants, molecular pharming, therapeutic products, RNAi, Transgene silencing, ethical issues.

TOTAL: 45 PERIODS

REFERENCES:

1. Grierson, D. & Covey, S.N. Plant Molecular Biology, 2nd Ed., Blackie, 1988.
2. Slater, A., Scott W.N. & Fowler. M.R. Plant Biotechnology: The Genetic Manipulation of Plants, 1st and 2nd Ed., Oxford University Press, 2003.
3. Gamburg, O.L. & Philips, G.C. (Eds.) Plant Tissue & Organ Culture: Fundamental Methods. Springer, 1995.

4. Heldt Hans-Walter, Plant Biochemistry & Molecular Biology, 1st Ed. Oxford University Press, 1997.
5. Wilkins, M.B. Advanced Plant Physiology, ELBS, Longman, 1987.

COURSE OUTCOMES:

1. Demonstrate the knowledge on the fundamentals of plant cells, structure and functions.
2. Interpret the chloroplast and mitochondrial genome function.
3. Identify the nitrogen fixation mechanism
4. Apply the plant tissue culture technique for creating transgenic plants
5. Examine different types of transgenic plants.

MA16091	**APPLIED MATHEMATICS FOR BIOTECHNOLOGISTS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I **9**

First order and second order-application to biology. Lagrange's method and Charpits method.

UNIT II **9**

Probability –Addition theorem, Multiplication theorem and conditional probability - Baye's theorem. Binomial distribution, Poisson distribution and Normal distribution.

UNIT III **9**

Curve fitting –fitting a straight line and second degree curve. Correlation and Regression. Fitting a non linear curve. Bivariate correlation application to biological sciences.

UNIT IV **9**

Sampling distributions-Large samples and Small samples. Testing of Null hypothesis-Z test, t test and 2 test. Type I and Type II errors. Fisher's F Test. Goodness of fit.

UNIT V **9**

Design of Experiments –One way, Two way classifications –Randomized Block Designs- Latin Square Designs.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Grewal, Higher Engineering Mathematics, 43rd Ed., Khanna publishers, 2014.
2. Arora, P.N., Sumeet Arora & Arora, S., Comprehensive Statistical Methods, S. Chand & Co, 2010.

REFERENCES:

1. Johnson, R.A., Miller and Freund's Probability and Statistics for Engineers, 6th Ed., Prentice Hall, 2004.
2. Merton R, Hubbard, Statistical Quality control for the Food Industry, Kluwer Academic/Plenum publishers, 2003.
3. Kapoor, V.C & Gupta., Mathematical Statistics, 2000.

COURSE OUTCOMES:

1. Acquire concepts of differential equations and linear equations needed for solving the problem in all engineering disciplines.
2. Understand standard techniques of linear programming to apply them with confidence in engineering field.
3. Demonstrate competency in correlation and regression.
4. Sampling and use statistical tests in testing hypotheses on data.
5. List the guidelines for designing experiments, recognize the key historical figures in Design of Experiments, conduct statistical tests and analyze the results.

MA16092	MATHEMATICS FOR BIOTECHNOLOGISTS	L	T	P	C
		3	0	0	3

UNIT I CALCULUS 12

Calculus (Quick review of concepts): Review of limits, continuity, differentiability; Mean value theorem, Taylor's Theorem, Maxima and Minima; Fundamental theorem of Calculus; Improper integrals; Applications to area, volume; Convergence of sequences and series; Power series; Partial Derivatives; Gradient and Directional derivatives; Chain rule; Maxima and Minima.

UNIT II DIFFERENTIAL EQUATION AND PARTIAL DIFFERENTIAL EQUATIONS 12

Introduction- Differential Equation and solution-First order, linear differential equation, partial differential equations solution-Various types of partial different equation of the form f(p,q)=0, f(x, p, q)=0, f(x, p)=g(y, q). Clairaut's form z=px+qy+f(p,q), Lagrange's equation Pp+Qq=R. Total differentiation Pdx+Qdy+Rdz=0. Simple Problem application to biology.

UNIT III SECOND AND HIGHER ORDER DIFFERENTIAL EQUATIONS 12

Linear ODE's with constant coefficients: the characteristic equations; Cauchy-Euler equations; Linear dependence and Wronskians; Method of undetermined coefficients; Method of variation of parameters; Laplace transforms: Inverse theorem, shifting theorems, partial fractions.

UNIT IV LINEAR ALGEBRA 12

Basics: Vectors, matrices, determinants; Matrix addition and multiplication; Systems of equations: Gauss elimination, Matrix rank, Linear independence, Cramer's rule; Inverse of a matrix: Gauss-Jordan elimination; Eigen values and Eigenvectors: characteristic polynomials, eigen values of special matrices (orthogonal, unitary, hermitian, symmetric, skew symmetric, normal).

UNIT V NUMERICAL METHODS 12

Solution of equations by iteration; Interpolation by polynomials; Piecewise linear and cubic splines; Numeric integration and differentiation; Linear systems: Gauss elimination, Gauss- Siedel, matrix inversion; LU factorization; Matrix eigenvalues; Numerical solution of ODEs: Euler and Runge -Kutta methods, Predictor-Corrector methods; Exposure to software packages like MATLAB or SCILAB.

TOTAL: 60 PERIODS

TEXT BOOKS:

1. Thomas, G.B & Finney, R.L., Calculus and Analytic Geometry, 9th Ed., ISE Reprint, Addison-Wesley, 1998.
2. Kreyszig, E., Advanced Engineering Mathematics, 8th Ed., John Wiley, 1999.
3. Boyce, W.E & DiPrima, R., Elementary Differential Equations, 8th Ed., John Wiley, 2005.
4. Grewal, Higher Engineering Mathematics, 43rd Ed., Khanna publishers, 2014.

COURSE OUTCOMES:

1. Express proficiency in handling higher order Partial differential equations.
2. Develop the skill to formulate and solve linear programming problems, Transportation and Assignment models.
3. Acquire knowledge to measure the degree of linear correlation and curve fitting.
4. Acquire knowledge of statistical techniques in making rational decision in research and management problems.
5. Classify and apply the related analysis of variance techniques in all fields of scientific experimentation.

BY16007	**ENVIRONMENTAL BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I

Microbial flora of soil, Ecological adaptations, Interactions among soil microorganisms, biogeochemical role of soil microorganisms. Biodegradation, Microbiology of degradation and its mechanism, Bioaugmentation, Biosorption, Bioleaching, Bioremediation - Types of Bioremediation, Bioreactors for Bioremediation, Metabolic pathways for Biodegradation for specific organic pollutants.

UNIT II

Pollution - Sources of pollutants for Air, Water (ground water, marine), Noise, Land and its characteristics - Pollution control and management - Environmental monitoring & sampling, Physical, chemical and biological methods and analysis - Air pollution - control and treatment strategies. Modes of Biological treatment methods for wastewater - aerobic digestion, anaerobic digestion, Anoxic digestion, the activated sludge process, Design and modeling of activated sludge processes, Aerobic digestion, Design of a trickling biological filter, Design of anaerobic digester.

UNIT III

Industrial waste management - Dairy, Paper & Pulp, Textile, leather, hospital and pharmaceutical industrial waste management, e-waste - radioactive and nuclear power waste management - Solid waste management.

UNIT IV

Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetically modified organisms in Waste management, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Phytoremediation for heavy metal pollution, Biosensors development to monitor pollution.

UNIT V

Alternate Source of Energy, Biomass as a source of energy, Biocomposting, Vermiculture,

Biofertilizers, Organic farming, Biofuels, Biomineralization, Bioethanol and Biohydrogen, Bio-electricity through microbial fuel cell, energy management and safety.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Chakrabarty K.D., Omen G.S., Biotechnology And Biodegradation, Advances In Applied Biotechnology Series, Vol.1, Gulf Publications Co., 1989.
2. Metcalf and Eddy, Waste water Engineering Treatment, Disposal and Reuse. 3rd Ed., Mc Graw Hill, 1991.
3. Forster, C. F and Waste, D.A. J. Environmental Biotechnology, Ellis Horwood Halsted Press. 1987.
4. Bailey, J. E. and Ollis, D. F., Biochemical Engineering Fundamentals, 2nd Ed., MacGraw Hill, 1986.
5. Alan Scragg, Environmental Biotechnology, Longman, 1999.
6. Bruce E. Rittmann, Eric Seagren, Brian A.Wrenn and Albert J. Valocchi, Chittaranjan Ray, Lutgarde Raskin, In-situ Bioremediation, 2nd Ed., Nayes Publication, 1991.
7. Old R.W., and Primrose, S.B., Principles of Gene Manipulation, 3rd Ed., Blackwell Science Publication, 1985.

REFERENCES:

1. Stanier R.Y., Ingraham J.L., Wheelis M.L., Painter R.R., General Microbiology, 5th Ed., Macmillan Publications, 1989.
2. G. Mattock E.D., New Processes of Waste water treatment and recovery, Ellis Horwood, 1978.
3. Jogdand, Environmental Biotechnology, 1st Ed., S.N. Himalaya Publishing House, 1995.
4. Young Murray Moo, Comprehensive Biotechnology (Vol. 1-4), Elsevier Sciences, 1985.
5. Standard Method for Examination of Water & Waste water, 14th Ed., American Public Health Association, 1985.
6. Lee, C.C. and Shun dar Lin, Handbook of Environmental Engineering Calculations, McGraw Hill, 1999.
7. Hendricks D, Water Treatment Unit Processes – Physical and Chemical, 1st Ed., CRC Press, 2006.
8. Martin A.M., Biological Degradation of Wastes, Elsevier Appl. Science, 1991.
9. Sayler, Gray S. Robert Fox and James W. Blackburn, Environmental Biotechnology for Waste Treatment, Plenum Press, 1991.

COURSE OUTCOMES:

1. Understand the microbial flora of the soil and its role in pollutant degradation.
2. Disccuss the principles of waste management and various treatment methods.
3. Describe the biotechnological processes for industrial waste management.
4. Compare and contrast various advanced technologies in waste management.
5. Identify the alternate source of energy for managing the safety of available resources

BY16008	**CLINICAL TRIALS AND BIOETHICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I **9**

Fundamentals of clinical trials; Basic statistics for clinical trials; Clinical trials in practice; Reporting and reviewing clinical trials; Legislation and good clinical practice - overview of the

European directives and legislation governing clinical trials in the 21st century; International perspectives; Principles of the International Committee on Harmonisation (ICH)-GCP.

UNIT II **7**

Drug development and trial planning - pre-study requirements for clinical trials; Regulatory approvals for clinical trials; Consort statement; Trial responsibilities and protocols - roles and responsibilities of investigators, sponsors and others; Requirements of clinical trials protocols; Legislative requirements for investigational medicinal products.

UNIT III **9**

Project management in clinical trials - principles of project management; Application in clinical trial management; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; Use of humans in Scientific Experiments; Ethical committee system including a historical overview; the informed consent; Introduction to ethical codes and conduct; Introduction to animal ethics; Animal rights and use of animals in the advancement of medical technology; Introduction to laws and regulation regarding use of animals in research.

UNIT IV **11**

Consent and data protection - the principles of informed consent; Consent processes; Data protection; Legislation and its application; Data management – Introduction to trial master files and essential documents; Data management.

UNIT V **9**

Quality assurance and governance - quality control in clinical trials; Monitoring and audit; Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls-trial closure; Reporting and legal requirements; Common pitfalls in clinical trial management.

TOTAL: 45 PERIODS

REFERENCES:

1. Lee, Chi-Jen; Clinical Trials or Drugs and Biopharmaceuticals, CRC / Taylor &Francis, 2011.
2. Gary M. Matoren, The Clinical Research Process in the Pharmaceutical Industry, Marcel Dekker, 1984.

COURSE OUTCOMES:

1. Illustrate the importance of clinical trials and good clinical practices
2. Assess the protocols for investigating drug developement and trials
3. Demonstrate the risk assessment and ethics in employing animal models for drug trial
4. Discuss the importance of data management and protection
5. Identify the quality control in drug trial and pharmacovigilance.

GE16091 UNIX OPERATING SYSTEM AND PROGRAMMING LANGUAGE C++

L	T	P	C
3	0	0	3

UNIT I UNIX OPERATING SYSTEM **8**

Introduction to Operating Systems, Basic Commands in Unix, VI editor, filters, input/output redirection, piping, transfer of data between devices, shell scripts.

UNIT II INTRODUCTION TO C++ **10**

Programming methodologies - Introduction to Object Oriented Programming - Comparison of Procedural and Object Oriented languages - Basics of C++ environment, Data types, Control Flow Constructs, Library functions, Arrays.

UNIT III CLASSES **10**

Definition - Data members - Function members - Access specifiers – Constructors - Default constructors - Copy constructors – Destructors - Static members - This pointer - Constant members - Free store operators - Control statements.

UNIT IV INHERITANCE AND POLYMORPHISM **10**

Overloading operators – Functions – Friends - Class derivation - Virtual functions - Abstract base classes - Multiple inheritance.

UNIT V TEMPLATES AND FILE HANDLING **7**

Class templates - Function templates - Exception handling - File Handling.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Kochen, S.J. & Wood, P.H. Exploring the Unix System, Techmedia, 1999.
2. Bach, M.J. The design of Unix operating systems, Prentice Hall of India, 1999.
3. Lippman, S.B. The C++ Primer, Addison Wesley, 1998.
4. Deitel, P. & Deitel, H. C++ How to Program, 2nd Ed. Prentice Hall, 1998.
5. Balagurasamy, E. , Object-Oriented Programming using C++, Tata McGraw - Hill, 2002.

COURSE OUTCOMES:

1. Apply concepts of practicing life-long learning of UNIX in applied biological science
2. Develop knowledge and application of basics of C++ in biological applications
3. Explain about classes in C++
4. Apply inheritance and polymorphism in applied biological science.
5. Experiment with templates and file handling in C++

GE16092	COMMUNICATION SKILLS AND PERSONALITY DEVELOPMENT	L	T	P	C
		3	0	0	3

UNIT I PROCESS OF COMMUNICATION 9

Concept of effective communication - Setting clear goals for communication; Determining outcomes and results; Initiating communication; Avoiding breakdowns while communicating; Creating value in conversation; Barriers to effective communication; Nonverbal communication - Interpreting nonverbal cues; Importance of body language, Power of effective listening; recognizing cultural differences.

UNIT II PRESENTATION SKILLS 12

Formal presentation skills; Preparing and presenting using Over Head Projector, Power Point; Defending Interrogation; Scientific poster preparation & presentation; Participating in group discussions.

UNIT III TECHNICAL WRITING SKILLS 12

Types of reports; Layout of a formal report; Scientific writing skills: Importance of communicating Science; Problems while writing a scientific document; Plagiarism; Scientific Publication Writing: Elements of a Scientific paper including Abstract, Introduction, Materials & Methods, Results, Discussion, References; Drafting titles and framing abstracts.

UNIT IV COMPUTING SKILLS FOR SCIENTIFIC RESEARCH 12

Web browsing for information search; search engines and their mechanism of searching; Hidden Web and its importance in scientific research; Internet as a medium of interaction between scientists; Effective email strategy using the right tone and conciseness.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mohan Krishna and N.P. Singh, Speaking English effectively, 2nd Ed., Macmillan, 2003.

COURSE OUTCOMES:

1. Develop skills on effective communication and body language
2. Illustrate the importance of presentation in various technological aspects
3. Demonstrate the quality of technical writing skills and plagiarisms
4. Discuss the appliation of computing skills for scientific research

BY16009 ENZYME TECHNOLOGY AND INDUSTRIAL APPLICATIONS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION **9**

Introduction to enzymes - Classification, Sources, Mechanism of enzyme action. Strategies of purification of enzymes, Criteria of purity, Molecular weight determination and characterization of enzymes. Enzymes of biological importance – Acetyl cholinesterase, Angiotensin Converting Enzyme (ACE), ACE Inhibitors, HMG CoA Reductase inhibitors, Pseudocholinesterase, 5 - Nucleotidase (5NT), Glucose-6-Phosphate Dehydrogenase (GPD), Creatine Kinase (CK) isoforms, Immuno Reactive Trypsinogen (IRT) Chymotrypsin and Amylase isoenzymes.

UNIT II KINETICS OF ENZYME ACTION **9**

Methods for investigating the kinetics of Enzyme catalyzed reactions – Initial velocity Studies, Estimation of Michaelis-Menten parameters, Effect of pH and temperature on enzyme activity, Kinetics of inhibition. Modeling of rate equations for single and multiple substrate reactions.

UNIT III IMMOBILIZED ENZYMES **9**

Techniques of enzyme immobilization - Kinetics of immobilized enzymes, Effect of solute, Partition & Diffusion on the kinetics of immobilized enzymes. Design and configuration of immobilized enzyme reactors. Applications of immobilized enzyme technology. Economic argument for immobilization.

UNIT IV ENZYMES IN FUNCTIONAL GROUP TRANSFORMATION **9**

Functional group inter conversion using enzymes (Hydrolysis reaction, Oxidation/Reduction reactions, C-C bond formations). Retrosynthetic bio catalysis and Chemo enzymatic synthesis of natural products. Industrial process using enzymes for production of drugs, fine chemicals and chiral intermediates.

UNIT V ENZYMATIC TRANSFORMATION **9**

Reaction engineering for enzyme - catalyzed bio transformations. Catalytic antibodies. Biocatalysts from extreme Thermophilic and Hyper thermophilic microorganisms (extremozymes). The design and construction of novel enzymes and artificial enzyme. Biotransformation of drugs (hydroxylation of Steroids). Host Guest Complexation chemistry. Enzyme design using steroid templates.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Blanch, H.W. & Clark, D.S. “Biochemical Engineering.” 2nd ed., Marcel Dekker, 1997.
2. James, M L. “Biochemical Engineering.” 1st ed., Prentice-Hall Inc., 1982.
3. Bailey, J.E. & Ollis, D.F. “Biochemical Engineering Fundamentals.” 2nd ed., McGrawHill, 1986.
4. Faber, K. “Biotransformations in Organic Chemistry: A Textbook.” 5th ed., Springer, 2008.
5. Palmer, T. “Enzymes: Biochemistry, Biotechnology, Clinical Chemistry.” 2nd ed,, East West Press, 2008.

COURSE OUTCOMES:

1. Explain the concept of enzymatic reactions in biological systems.
2. Identify the theoretical and practical aspects of enzyme kinetics in bioprocess applications.

3. Compare various immobilization techniques to improve enzyme stability.
4. Identify suitable techniques for production and purification of enzymes.
5. Identify and apply suitable enzymes for various industrial and research applications.

BY16010	ADVANCED PROCESS CONTROL FOR BIOTECHNOLOGISTS	L	T	P	C
		3	0	0	3

UNIT I ANALYSIS AND DESIGN OF FEED BACK CONTROL SYSTEM 9

Dynamic behavior, Stability analysis. Design of feedback controllers, design of feedback control systems using frequency response techniques, PID controller for multi-capacity processes.

UNIT II OPTIMUM CONTROLLER SETTING 9

Optimum settings from the plant response: continuous cycling method, damped oscillation method and reaction curved method.

UNIT III ANALYSIS AND CONTROL OF ADVANCED CONTROL SYSTEMS 9

Feedback control of systems with large dead time, control systems with multiple loops, feed forward and ratio control, adaptive and inferential control systems.

UNIT IV AUTOMATIC CONTROLLERS 9

Electronic controllers, operational amplifier. Electronic controller: input and output, PID and on-off control models. Microprocessors: general architecture, algorithms, applications in chemical process control.

UNIT V PROCESS CONTROL USING DIGITAL COMPUTERS 9

Characteristics and performance of control computers, signals-types, signal transmission, analog feedback control systems. The direct digital control concept, advantages of DDC. Computer process interface for data acquisition and control, computer control loops.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. George, S. Chemical Process Control- An introduction to Theory and Practice, 1st Ed., Prentice Hall of India Pvt.Ltd, 1990.
2. Emanule, S. S. Computer control of industrial processes, 1st Ed., McGraw Hill, 1965.
3. Peter, H. Process Control, 1st Ed., Tata McGraw Hill Publishing Co, 1977.

COURSE OUTCOMES:

1. Analyze and solve problems in process systems -in particular those dealing with equipment performance, fluid flow, and material and energy balances.
2. Explore on the fundamental principles of equipment operation and thier working strategies.
3. Identify suitable computer programs to solve the process control problems.
4. Interprete various process control informations with the the knowledge of data acquisition.
5. Achieve rewarding careers in bioprocess engineering and related fields after graduation.

BY16011 BIOPROCESS MODELING AND SIMULATION

L	T	P	C
3	0	0	3

UNIT I MODELING OF BIOLOGICAL SYSTEMS **9**

Modeling Principles: Model development from first principles. Modeling approaches for Biological systems – structured and unstructured systems; Compartment models; Deterministic and stochastic approaches for modeling structured systems.

UNIT II MODELLING OF DIFFUSION SYSTEMS (BIOFILM) AND IMMOBILIZED ENZYME SYSTEMS **9**

External mass transfer, Internal diffusion and reaction within biocatalysts, Derivation of finite model for diffusion - reaction systems, Dimensionless parameters from diffusion-reaction models, the effectiveness factor concept: case studies; Oxygen diffusion effects in a biofilm, Biofilm nitrification.

UNIT III MODELING BIOREACTOR **9**

Bioreactor modelling: Ideal and non-ideal bioreactors; Stirred tank models; characterization of mass and energy transfer distributions in stirred tanks, Tower Reactor Model; Flow modeling, Bubble column flow models, Mass transfer modeling, Structured models for mass transfer in tower reactors, Process models in tower reactors, Airlift models.

UNIT IV LINEAR SYSTEM ANALYSIS **9**

Study of linear systems, Linearization of non-linear systems; Simulation of linear models using MATLAB; Parameter estimation and sensitivity analysis; Steady state and unsteady state systems; stability analysis; Case study of recombinant protein production.

UNIT V HYBRID AND OTHER MODELING TECHNIQUES **9**

Advanced modeling techniques such as fuzzy logic, neural network, Hybrid systems and fuzzy logic systems; case studies.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Bequettre, B.W. Bio Process Dynamics Modeling, 1st Ed., Analysis and Simulation, Prentice-Hall, 1998.
2. Said, S.E.H & Elnashaie, G. P. Conservation Equations and Modeling of Chemical and Biochemical Processes, 1st Ed., Taylor & Francis, 2003.

REFERENCES:

1. Dunn, I.J. Biological Reaction Engineering: Dynamic Modeling Fundamentals with Simulation Examples, 2nd Ed., Wiley-VCH Publishing, 2003.

COURSE OUTCOMES:

1. Impart knowledge on design and operation of fermentation processes with all its prerequisites
2. Provide the students with the basics of bioreactor engineering.
3. Apply modelling and simulation of bioprocesses so as to reduce costs and to enhancethe quality of products and systems.
4. Integrate research lab and Industry; identify problems and seek practical solutions for large scale implementation of Biotechnology.

BY16012 PLANT DESIGN AND PRACTICE

L	T	P	C
3	0	0	3

UNIT I PLANT DESIGN 12

Fermenter design, Vessels for biotechnology, Piping and Valves for biotechnology, Pressure relief system. Materials of construction and properties. Utilities for plant and their design.

UNIT II PROCESS ECONOMICS 8

General fermentation: Process economics, Materials usage and cost, Capital investment estimate, Production cost estimate. Two case studies – one traditional product and one recombinant product.

UNIT III PHARMACEUTICAL WATER SYSTEM 7

Grades of water, Sanitary design, Water treatment system, Water distribution system, Validation.

UNIT IV VALIDATION OF BIOPHARMACEUTICAL FACILITIES 8

Introduction: Why validation?, When does validation occur?, Validation structure, Resources for validation, Validation of systems and processes including SIP and CIP.

UNIT V GOOD MANUFACTURING PRACTICES 10

Structure – quality management, Personnel, Premises and Equipment, Documentation, Production, Quality control, Contract manufacturing and analysis, Complaints and product recall, Self inspection. GLP and its principles.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Peters, M., Timmerhaus, K & West, R. Plant Design and Economics for Chemical Engineers, 4th Ed., McGraw-Hill Publishing Company Limited, 1991.
2. Butterworth, H. A compendium of Good Practices in Biotechnology, BIOTOL Series, 1993.
3. Seiler, J P. Good Laboratory Practice - the Why and the How? 2nd Ed., Springer, 2005.
4. Lydersen, B.K., D'Elia, N. A. & Nelson K.L. Bioprocess Engineering: Systems, Equipment and Facilities, Wiley, 1994.

COURSE OUTCOMES:

1. Acquire deep knowledge about the materials for the design of the fermenters
2. Infer the theoretical and practical aspects of economics involved in design fermenter based on the value of products produced
3. Analyse the significance of pharmaceutical facilities in the production of the products
4. Demonstrate the good manufacturing practices to be followed in each sectors of the plant

BY16013 COMPUTER AIDED LEARNING OF STRUCTURE AND FUNCTION OF PROTEINS

L	T	P	C
3	0	0	3

UNIT I COMPONENTS OF PROTEIN STRUCTURE **9**

Introduction to proteins, structure and properties of amino acids, the building blocks of proteins, Molecular Interactions and their roles in protein structure and function, Primary Structure – methods to determine and synthesis.

UNIT II PROTEIN BIOINFORMATICS **9**

Protein sequence and structural databases, Multiple sequence alignment, Secondary, Tertiary and Quaternary Structure of Proteins. Sequence and Structural Motifs. Protein folding.

UNIT III OVERVIEW OF STRUCTURAL AND FUNCTIONAL PROTEINS **9**

Classes of Proteins and their Structure-Function Relationships – alpha, beta, alpha/beta proteins, DNA-binding proteins, Enzymes, IgG, membrane proteins.

UNIT IV PROTEIN STRUCTURAL CLASSIFICATION DATABASES **9**

SCOP and CATH. Evolutionary relationships and Phylogenetic Studies.

UNIT V PROTEIN MODIFICATIONS **9**

Post translational modifications, Engineering of proteins, Site directed mutagenesis, Fusion Proteins, Chemical derivatization.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Voet, D.J., Voet, G.J. & Pratt, C.W. Fundamentals of Biochemistry, 3rd ed., John Wiley & Sons Inc, 2004.
2. Branden, C & Tooze, J. Introduction to Protein Structure, 2nd ed., Garland Science, 1999.
3. Creighton, T E. Proteins: Structures and Molecular Properties, 2nd ed., W. H. Freeman, 1993.

COURSE OUTCOMES:

1. Analyze the various interactions in protein
2. Differentiate the various levels of protein structure
3. Classification of proteins databases based on structure
4. Examine the evolutionary relationship in proteins for engineering function
5. Analyze the various methods for protein modification.

BY16014 METABOLIC PROCESS AND ENGINEERING

L	T	P	C
3	0	0	3

UNIT I METABOLIC FLUX ANALYSIS **9**

Introduction to metabolic engineering, comprehensive models of cellular reactions with stoichiometry and reaction rates, metabolic flux analysis of exactly/over/under determined systems. Shadow price, sensitivity analysis.

UNIT II TOOLS FOR EXPERIMENTALLY DETERMINING FLUX THROUGH PATHWAYS **9**

Monitoring and measuring the metabolome, Methods for the experimental determination of

metabolic fluxes by isotope labeling, metabolic fluxes using various analytical separation techniques. GC-MS for metabolic flux analysis, genome wide technologies - DNA /phenotypic microarrays and proteomics.

UNIT III CONSTRAINT BASED GENOMIC SCALE METABOLIC MODEL 9

Development of Genomic scale metabolic model, in silico Cells - studying genotype-phenotype relationships using constraint-based models, case studies in E. coli, S. Cerevisiae. Metabolic network reconstruction methods, optimization of metabolic network, Identification of targets for metabolic engineering, software and databases for genome scale modeling.

UNIT IV METABOLIC CONTROL ANALYSIS AND KINETIC MODELING 9

Fundamentals of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients. Multi-substrate enzyme kinetics, engineering multifunctional enzyme systems for optimal conversion, multi scale approach for the predictive modeling of metabolic regulation.

UNIT V CASE STUDIES IN METABOLIC ENGINEERING 9

Metabolic engineering examples for bio-fuel, bio-plastic and green chemical synthesis. Study of genome scale model in various systems for the production of green chemicals using software tools. Validation of the model with experimental parameters.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Stephanopoulos, G.N., Aristidou A. A. & Nielsen, J. Metabolic Engineering Principles and Methodologies, 1st Ed., Academic Press, 1998.
2. Lee, S.Y. & Papoutsakis, E.T. Metabolic Engineering, 1st ed., Marcel Dekker, 1998.
3. Nielsen, J., Villadsen, J. & Lidén, G. Bioreaction Engineering Principles, 3rd ed., Springer, 2011.
4. Smolke, C D. The Metabolic Pathway Engineering Handbook Fundamentals, 1st ed., CRC Press, 2010.

REFERENCES:

1. Voit, E.O. Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists, 1st ed., Cambridge University Press, 2000.
2. Scheper, T. Metabolic Engineering Advances in Biochemical Engineering / Biotechnology, Vol 73 Springer, 2001.
3. Cortassa, S., Aon, M. A., Iglesias, A. A. & Llyod, D. An Introduction to Metabolic and Cellular Engineering, 1st ed., World Scientific Publishing Co. Pte. Ltd, 2002.
4. Kholodenko, B.N. & Westerhoff H.V. Metabolic Engineering in the Post Genomic Era,1st ed., Horizon Bioscience, 2004.

COURSE OUTCOMES:

1. Summarize metabolic flux analysis
2. Develop tools for experimentally determining flux through pathways
3. Construct constraint based genomic scale metabolic model
4. Determine metabolic control, kinetic modeling and analysis
5. Evaluate metabolic Enineering using case studies

BY16015 COMPUTATIONAL FLUID DYNAMICS FOR BIOTECHNOLOGISTS

L	T	P	C
3	0	0	3

UNIT I FLUID DYNAMICS **5**

Introduction, Reasons for CFD. Typical examples of CFD codes and their use. Validation strategies. Derivation of Governing Equations of Fluid Dynamics - Mass conservation and divergence, Navier-Stokes and Euler equations, Energy equations, Conservation formulation and finite volume discretisation. Partial differential equations - classification, characteristic form. PDEs in science and engineering.

UNIT II BASIC NUMERICS **10**

Mathematical behavior of hyperbolic, parabolic and elliptic equations. Well posedness. Discretization by finite differences. Analysis of discretized equations - order of accuracy, convergence and stability (von Neumann analysis). Numerical methods for model equations related to different levels of approximation of Navier Stokes equation - linear wave equation, Burgers equation, convection-diffusion equation. First and second order numerical methods such as upwind, Lax-Friedrichs, Lax-Wendroff, MacCormack, etc. Modified equation - dissipation and dispersion.

UNIT III COMPRESSIBLE FLOW **10**

Euler equations, conservative/non-conservative form thermodynamics of compressible flow, scalar conservations laws - Conservation, weak solutions, non-uniqueness, entropy conditions. Shock formation, Rankine-Hugoniot relations. Numerical methods for scalar conservation laws. Properties of the numerical scheme such as CFL-condition, conservation and TVD. First order methods. System of conservations laws. Numerical methods for Euler equations - MacCormack and artificial viscosity for non-linear systems. Numerical/physical boundary conditions. Shock tube problem. High resolution schemes for conservations laws. Numerical methods for Euler equations. Boundary conditions, Riemann invariants. Compressible flow in 2D. Numerical methods for Euler equations, cont. Grids, algebraic mesh generation by transfinite inter-polation. Flow around an airfoil.

UNIT IV FINITE VOLUME AND FINITE DIFFERENCE METHODS **10**

Laplace equation on arbitrary grids, equivalence with finite-differences, linear systems - Gauss-Seidel as smothers for multi-grid. Staggered grid/volume formulation. Unsteady equations - projection and MAC method, discrete Poisson pressure equation. Time step restrictions. Steady equations - distributive iteration and SIMPLE methods.

UNIT V FINITE ELEMENTS **10**

Diffusion problem. Variational form of the equation, weak solutions, essential and natural boundary condition. Finite-element approximations, stability and accuracy, the algebraic problem, matrix assembly. Navier–Stokes equations. Mixed variational form, Galerkin and FE approximations, and the algebraic problem. Stability, the LBB condition, mass conservation.

TOTAL: 45 PERIODS

REFERENCES:

1. Randall, J. L. Finite Volume Methods for Hyperbolic Problems, 2nd ed., Cambridge University Press, 2004.
2. Klaus, A. H & Steve, T. C. Computational fluid dynamics, 4th ed., Engineering Education system, 2000.
3. Tannehill, J.C., Anderson, D.A & Pletcher, R.H. Computational Fluid Mechanics and Heat Transfer, 3rd ed., CRC Press, 2012.

COURSE OUTCOMES:

1. Explain the validation of fluid flow in computational aspects
2. Examine the numerical modeling of fluid dynamics and heat transfer
3. Compare the flow processes by using different pressure bound algorithms.
4. Interpret the discretion methods for solving problems in dynamics of fluid
5. Analyse the diffusion problem using finite elements.

BY16016	**GENOMICS AND PROTEOMICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I OVERVIEW OF GENOMES **9**

Genomes of Bacteria, archae and eukaryote.

UNIT II PHYSICAL MAPPING TECHNIQUES **9**

Top down and bottom up approach; linking and jumping of clones; genome sequencing; placing small fragments on map; STS assembly; gap closure; pooling strategies; cytogenetic mapping techniques.

UNIT III FUNCTIONAL GENOMICS **9**

Gene finding; annotation; ORF and functional prediction; Substractive DNA library screening; differential display and representational difference analysis; SAGE; TOGA.

UNIT IV PROTEOMICS TECHNIQUES **9**

Protein level estimation; Edman protein microsequencing; protein cleavage; 2D gel electrophoresis; metabolic labeling; detection of proteins on SDS gels; pattern analysis; Mass spectrometry - principles of MALDI-TOF; Tandem MS-MS; Peptide mass fingerprinting.

UNIT V PROTEIN PROFILING **9**

Post translational modification; protein-protein interactions; glycoprotein analysis; phosphoprotein analysis.

TOTAL: 45 PERIODS

REFERENCES:

1. Cantor, C.R. & Smith, C.L. Genomics: The Science and Technology - Behind the Human Genome Project, John Wiley & Sons Limited, 1999.
2. Pennington, S.R. & Dunn, M.J. Proteomics: From Protein Sequence to Function, Bio Scientific Publishers Limited, 2001.

3. Liebler, D.C. Introduction to Proteomics: Tools for the New Biology, Humana Press, 2002.
4. Hunt, S.P. & Livesey, F.J. Functional Genomics, Oxford University Press, 2000.
5. Primrose, S.B. Principles of genome analysis: A guide to Mapping and Sequencing DNA from Different Organisms, 2nd Ed., Blackwell Science, 1998.

COURSE OUTCOMES:

1. Discover the genomic features of Bacteria, archae and eukaryote from its genome sequences.
2. Understand the importance of physical mapping techniques in genome assembly
3. Apply functional genomics techniques to analyse data for biological system
4. Develop basic skills and techniques involved in extraction and quantification of proteins
5. Analyze the post translational modifications in various protein samples.

BY16017	**MOLECULAR THERAPEUTICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I GENE THERAPY **9**

Gene therapy - Intracellular barriers to gene delivery, Overview of inherited and acquired diseases for gene therapy, Retro and Adeno virus mediated gene transfer, Liposome and nanoparticles mediated gene delivery.

UNIT II CELLULAR THERAPY **9**

Cellular therapy- Stem cells definition, properties and potency of stem cell, Sources - embryonic and adult stem cells, Concept of tissue engineering - Role of scaffolds, Role of growth factors, Role of adult and embryonic stem cells, Clinical applications, Ethical issues.

UNIT III RECOMBINANT THERAPY **9**

Recombinant therapy - Clinical applications of recombinant technology, Erythropoietin, Insulin analogs and its role in diabetes, Recombinant human growth hormone, Streptokinase and urokinase in thrombosis, Recombinant coagulation factors.

UNIT IV IMMUNOTHERAPY **9**

Immunotherapy - Monoclonal antibodies and their role in cancer, Role of recombinant interferons, Immuno-stimulants, Immuno-supressors in organ transplants, Role of cytokine therapy in cancers, Vaccines - types, recombinant vaccines and clinical applications.

UNIT V GENE SILENCING TECHNOLOGY **9**

Gene silencing technology - Antisense therapy, si RNA, Tissue and organ transplantation, Transgenics and their uses, Cloning, Ethical issues.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Bernhard, O. P & Sangeeta, N. B. Tissue Engineering, 2nd ed., Prentice Hall, 2009.
2. Pamela, G & Michelle, M. Molecular Therapeutics: 21st Century Medicine, John Wiley & Sons Limited, 2008.

COURSE OUTCOMES:

1. Outline the fundamentals of gene therapy and the tools used in it.
2. Relate the tissue Engineering fundamentals and its therapeutic application.
3. Construct the protein based recombinant therapeutics.
4. Illustrate the immunotherapy and its application.
5. Translate the application of gene silencing into therapy.

BY16018	ADVANCES IN MOLECULAR PATHOGENESIS	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION **5**

Discovery of microscope, Molecular Koch's postulates, Concepts of disease, Virulence, Pathogenic cycle, Vaccines and its historical perspective, Biofilms, quorum sensing, multidrug resistance.

UNIT II HOST DEFENSE AGAINST PATHOGENS AND BACTERIAL DEFENSE STRATEGIES **10**

Skin, mucosa, cilia secretions, physical movements, physical and chemical barriers to bacterial colonization, Mechanism of killing by humoral and cellular defenses, Complement, Inflammatory process, Phagocytosis, Colonization, Adherence, Iron acquisition mechanisms, Bacterial defense strategies.

UNIT III MOLECULAR MECHANISMS OF VIRULENCE **10**

Virulence, Colonization factors, Microbial toxins, Secretion systems: General secretory pathway, Two-step secretion, Contact dependent secretion, Conjugal transfer system and Autotransporters.

UNIT IV MECHANISMS UNDERLYING MOLECULAR PATHOGENESIS (Common Enteric Pathogens) **10**

Shigella: Entry, Induction of macropinocytosis, Invasion of epithelial cells, Intracellular motility and spread, Apoptotic killing of macrophages, Virulence factors involved. E. coli: Entero-toxigenic E. coli (ETEC), labile & stable toxins, Entero-pathogenic E. coli (EPEC), type III secretion, Cytoskeletal changes, intimate attachment; Entero-haemerrohogic E. coli (EHEC), Mechanism of bloody diarrhea and Hemolytic Uremic Syndrome, Entero-aggregative E. coli (EAEC). Vibrio Cholerae: Cholera toxin, Co-regulated pili, filamentous phage, survival.

UNIT V MECHANISMS UNDERLYING MOLECULAR PATHOGENESIS (Common Non-Enteric Pathogens) **10**

Mycobacterium tuberculosis: The Mycobacterial cell envelope, Route of entry, Uptake by macrophages, Latency and persistence, Entry into and survival in phagocytes, Immune response against MTB, MTB virulence factors, Emergence of resistance. Influenza virus: Intracellular stages, Neuraminidase and Haemagglutinin in entry, M1 & M2 proteins in assembly and disassembly, action of amantadine. Plasmodium: Lifecycle, erythrocyte stages, transport mechanism and processes to support the rapidly growing schizont, parastiparous vacuoles and knob protein transport, Antimalarials based on transport processes.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Abigail, A.S. Bacterial Pathogenesis- A Molecular Approach, 3th ed., ASM press, 2010.
2. Groisman. Principles of Bacterial Pathogenesis, 1st ed., Academic Press, 2000.
3. Gabriel, W & Michael,C. Structural Biology of Bacterial Pathogenesis, ASM press, 2005.
4. Virginia, L.C. Bacterial Pathogenesis, 1st ed., Academic press, 2002.
5. Peter, W., Julian, K & George, S. Methods in Microbiology – Bacterial Pathogenesis, 1st ed., Academic press, 1998.
6. Bruce, A.M. Microbial Pathogenesis, 1st ed, Wiley-blackwell, 1999.
7. Michael, T.M. Biology of Microorganisms, 13th ed., Benjamin Cummings, 2010.
8. Stanley. Genetic analysis of Pathogenic bacteria, A Laboratory Manual. CSHL press, 1996.
9. Jorg, H. Molecular Infection Biology, Spektrum Akademischer , 2002.

COURSE OUTCOMES:

1. Explain the concept of biofilm and multidrug resistant pathogens
2. Illustrate the host defence mechanisms against pathogens
3. Outline the mechanisms of virulence and signalling molecules in microbes
4. Examine the pathogenesis of various enteric microrganisms and thier survillience on host.
5. Relate the pathogenesis of non-enteric organisms with drug resistance developement

BY16019	**NANOBIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

UNIT I NANOSCALE AND NANOBIOTECHNOLOGY 6

Introduction to Nanoscience and Nanotechnology; Milestones in Nanotechnology; Overview of Nanobiotechnology and Nanoscale processes; Physicochemical properties of materials in Nanoscales.

UNIT II FABRICATION AND CHARACTERIZATION OF NANOMATERIALS 10

Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Buckyballs, Nanotubes); Gas, liquid, and solid–phase synthesis of nanomaterials; Lithography techniques (Photolithography, Dip-pen and Electron beam lithography); Thin film deposition; Electrospinning; Bio-synthesis of nanomaterials.

UNIT III PROPERTIES AND MEASUREMENT OF NANOMATERIALS 9

Optical Properties: Absorption, Fluorescence, and Resonance; Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging.

UNIT IV NANOBIOLOGY AND BIOCONJUGATION OF NANOMATERIALS 10

Properties of DNA and motor proteins; Lessons from nature on making nanodevices; Reactive groups on biomolecules (DNA & Proteins); Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires; Nanofluidics to solve biological problems.

UNIT V NANO DRUG DELIVERY AND NANOMEDICINE 10

Properties of nanocarriers; drug delivery systems used in nanomedicine; Enhanced Permeability

and Retention effect; Blood-brain barrier; Active and passive targeting of diseased cells; Health and environmental impacts of nanotechnology.

TOTAL: 45 PERIODS

REFERENCES:

1. Niemeyer, C.M. & Mirkin, C.A. Nanobiotechnology: Concepts, Applications and Perspectives, 1st Ed, Wiley-VCH, 2004.
2. Shoseyov, O. & Levy, I. NanoBioTechnology: BioInspired Devices and Materials of the Future, 1st Ed, Humana Press, 2007.
3. Rosenthal, S.J. & Wright, D. W. NanoBiotechnology Protocols (Methods in Molecular Biology), 1st Ed, Humana Press, 2005.
4. Madhuri, S., Maheshwar, S., Pandey, S. & Oza, G. Bio-Nanotechnology Concepts and applications, 1st Ed, Ane Books Pvt Ltd, 2012.
5. Clarke, A.R. & Eberhardt, C.N. Microscopy Techniques for Material Science, 1st Ed, CRC Press, 2002.

COURSE OUTCOMES:

1. Explain the fundamentals of nanotechnology
2. Illustrate the fabrication of nanomaterials for the effective drug delivery
3. Examine the technologies for the characterization of nanoparticles
4. Design of bioconjugation of nanomaterials to solve biological problems
5. Analyse the impact of nanotechnology in drug delivery.

BY16020	**ANIMAL BIOTECHNOLOGY**	**L T P C**
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UNIT I INTRODUCTION **4**

Scope of Animal Biotechnology, Animal Biotechnology for production of regulatory proteins, blood products, vaccines, hormones and other therapeutic proteins.

UNIT II MOLECULAR BIOLOGY **9**

Biology of animal viral vectors-SV40, adeno virus, retrovirus, vaccinia virus, herpes virus, adeno associated virus and baculo virus.

UNIT III CELL CULTURE TECHNOLOGY **11**

Culturing of cells, primary and secondary cell lines, Cell culture-Scaling up of animal cell culture - monolayer culture, suspension culture; Various bio-reactors used for animal cell culture - Roller bottle culture; Bioreactor process control, stirred animal cell culture, Air-lift fermentor, Chemostat/Turbidostat; High technology vaccines; Hybridoma technology; Cell lines and their applications.

UNIT IV GENETIC ENGINEERING **11**

Gene therapy-prospects and problems; Knockout mice and mice model for human genetic disorder; Baculo virus in bio control; Enzymes technology, Somatic manipulation of DNA, Nucleic acid hybridization and probes in diagnosis- preparation of probes, evaluation and applications.

UNIT V APPLICATIONS **10**

Rumen manipulation - probiotics embryo transfer technology, *in vitro* fertilization, transgenesis - methods of transferring genes into animal oocytes, eggs, embryos and specific tissues by physical, chemical and biological methods; Bio-pharming-Transgenic animals (Mice, Cows, Pigs, Sheep, Goat, Birds and Insects); Artificial insemination and embryo transfer.

TOTAL: 45 PERIODS

TEXTBOOKS/REFERENCES

1. Watson, J.D., Gilman, M., Witowski, J. & Zoller, M. Recombinant DNA, 2nd ed., Scientific American Books, 1983.
2. Glick, B.R. & Pasternack, J.J. Molecular Biotechnology, 3rd ed., ASM Press, 2003.
3. Lewin, B. Genes IX, 11th ed., Pearson Prentice Hall, 2004.
4. Davis, J.M. Basic Cell Culture: A Practical Approach, 1st ed, IRL Press, 1998.
5. Freshney, R.I. Animal Cell Culture- a practical approach, 5th ed, Wiley-Liss, 2005.

COURSE OUTCOMES:

1. Explain products procuded by Animal Biotechnology
2. Identify molecular biology of gene transfer using viral vector
3. Experiment with scaling up, reactor, production with cell cultures
4. Inspect use of Genetic Engineerig for manipulation, therapy and diagnosis
5. Construct gene transfer method to use animal as bioreactor.